3.2 Near-Facility Environmental Monitoring

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Near-facility (near-field) environmental monitoring is defined as routine monitoring near facilities that have potential to discharge, or have discharged, stored, or disposed of radioactive or hazardous contaminants. Monitoring locations are associated with nuclear facilities such as the Plutonium Finishing Plant and the K Basins; inactive nuclear facilities such as N Reactor and Plutonium-Uranium Extraction Plant; and waste storage or disposal facilities such as burial grounds, cribs, ditches, ponds, tank farms, and trenches.

Much of the monitoring program consists of collecting and analyzing environmental samples and methodically surveying areas near facilities releasing effluents and waste streams. The program is also designed to evaluate acquired analytical data, determine the effectiveness of facility effluent monitoring and controls, measure the adequacy of containment at waste disposal units, and detect and monitor unusual conditions. The program implements applicable portions of DOE Orders 435.1, 5400.1, 5400.5, and 5484.1; 10 CFR 835 and 40 CFR 61; and WAC 246-247.

Near Hanford Site facilities, several types of environmental media are sampled, and various radiological and nonradiological measurements are taken to monitor the effectiveness of effluent treatment and control practices, diffuse source emissions, and contamination control in waste management and restoration activities. These include air, surface and spring water, surface contamination, soil and vegetation, external radiation, and investigative samples (which can include wildlife). Samples are collected from known or expected effluent pathways. These pathways are generally downwind of potential or actual airborne releases and downgradient of liquid discharges.

Active and inactive waste disposal sites and the terrain surrounding them are surveyed to detect and characterize radioactive surface contamination. Routine survey locations include cribs, trenches, retention basin perimeters, pond perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the site operational areas.

Sampling and analysis information and analytical results for 1999 are summarized in the following sections. Additional data may be found in *Hanford Site Near-Facility Environmental Monitoring Data Report for Calendar Year 1999* (PNNL-13230, APP. 2). Near-facility monitoring in 1999 is summarized in Table 3.2.1, which shows the type, quantity, and general location of samples collected.

3.2.1 Air Monitoring

Monitoring for radioactivity in air near Hanford Site facilities used a network of continuously operating samplers at 85 locations (Table 3.2.2) (sampling locations illustrated in PNNL-13230, APP. 2). Air samplers were located primarily at or within ~500 meters (1,500 feet) of sites and/or facilities having the potential for, or history of, environmental releases, with an emphasis on the prevailing

Table 3.2.1. Near-Facility Routine Environmental Monitoring Samples and Locations, 1999

Sample Type	Number of Sample Locations	Operational Area									
		100-B,C	100-D,DR	100-K	100-F	100-H	100-N	ERDF[a]	200/600	300/400	TWRS[b]
Air	85	5	11	8	2	4	4	3	42[c]	6	0
Water	10	0	0	0	0	0	10	0	0	0	0
External radiation	143	5	5	11	0	3	22	3	63	21	10
Soil	83	2	2	0	0	2	5	1	58	13	0
Vegetation	70	0	0	0	0	0	10	0	47	13	0

(a) Environmental Restoration Disposal Facility in the 200-West Area.
(b) Tank Waste Remediation System in the 200-East Area.
(c) Includes one station at the Wye Barricade, one at the former Gable Mountain Pond, 19 in the 200-East Area, and 21 in the 200-West Area.

downwind direction. To avoid duplication of sampling, air data for the 300 and 400 Areas, some onsite remediation projects, and some offsite distant locations were obtained from existing Pacific Northwest National Laboratory air sampling stations.

Samples were collected according to a schedule established before the 1999 monitoring year. Airborne particles were sampled at each of these stations by drawing air through a glass-fiber filter. The filters were collected biweekly, field surveyed for gross radioactivity, held for at least 7 days, and then analyzed for gross alpha and beta activity. The 7-day holding period was necessary to allow for the decay of naturally occurring radionuclides that would otherwise obscure detection of longer-lived radionuclides associated with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the near-facility environment.

For most specific radionuclide analyses, the amount of radioactive material collected on a single filter during a 2-week period was too small to be measured accurately. The accuracy of the sample analysis was increased by compositing the samples into biannual samples for each location.

Figure 3.2.1 shows the average concentrations of selected radionuclides in the 100 and 200/600 Areas compared to the DOE derived concentration guides and air samples measured in distant communities. The DOE derived concentration guides (DOE Order 5400.5) are reference values that are used as indexes of performance. The data indicate a large degree of variability. Air samples collected from areas located at or directly adjacent to Hanford Site facilities had higher concentrations than did those samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels and much less than the DOE derived concentration guides. In all areas, the data also show that concentrations of certain radionuclides were higher within different operational areas. Table 3.2.3 shows the annual average and maximum concentration of radionuclides in near-facility air samples during 1999.

The 1999 analytical results for the 100-B,C, 100-D, and 100-H Areas remedial action projects generally indicated that for most radionuclides, concentrations were greater than levels measured off the site. The levels of strontium-90 at the 100-B,C site were noticeably higher than the offsite levels and were the highest measured on site in 1999. At the 100-B,C project, ambient air monitoring locations included one upwind Pacific Northwest National Laboratory sampler at the Yakima Barricade and five

Table 3.2.2. Near-Facility Air Sampling Locations and Analyses, 1999

Site	Number of Samplers	EDP Code[a]	Analyses	
			Biweekly	Composite
100-B,C remedial action project	5	N464, N465, N466, N496, N497	Gross alpha, gross beta	GEA,[b] Sr-90, Pu-iso,[c] U-iso[d]
100-D remedial action project	9	N467, N468, N469, N470, N511, N512, N513, N514, N515	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-DR interim safe storage project	2	N492, N493	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-F interim safe storage project	2	N494, N495	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
100-H remedial action project	4	N507, N508, N509, N510	Gross alpha gross beta	GEA, Sr-90, Pu-iso, U-iso
100-K spent nuclear fuels	8	N401, N402, N403, N404, N476, N477, N478, N479	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso, Pu-241, Am-241
100-N surveillance and maintenance/transition	4	N102, N103, N105, N106	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
200-East Area	17	N019, N158, N498, N499, N957, N967, N968, N969, N970, N972, N973, N976, N977, N978, N984, N985, N999	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
Canister Storage Building, 200-East Area	2	N480, N481	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso, Pu-241, Am-241
200-West Area	21	N155, N161, N165, N168, N200, N304, N433, N441, N442, N449, N456, N457, N956, N963, N964, N965, N966, N974, N975, N987, N994	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
300-FF-1 remedial action project (300 Area)	6	N130, N485, N486, N487, N488, N489	Gross alpha, gross beta	GEA, U-iso
600 Area	1	N981	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
Former Gable Mountain Pond	1	N516	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso
Environmental Restoration Disposal Facility	3	N482, N483, N484	Gross alpha, gross beta	GEA, Sr-90, Pu-iso, U-iso

(a) EDP Code = Sampler location code. See PNNL-13230, APP. 2.
(b) GEA = Gamma energy analysis.
(c) Isotopic plutonium-238 and -239/240.
(d) Isotopic uranium-234, -235, and -238.

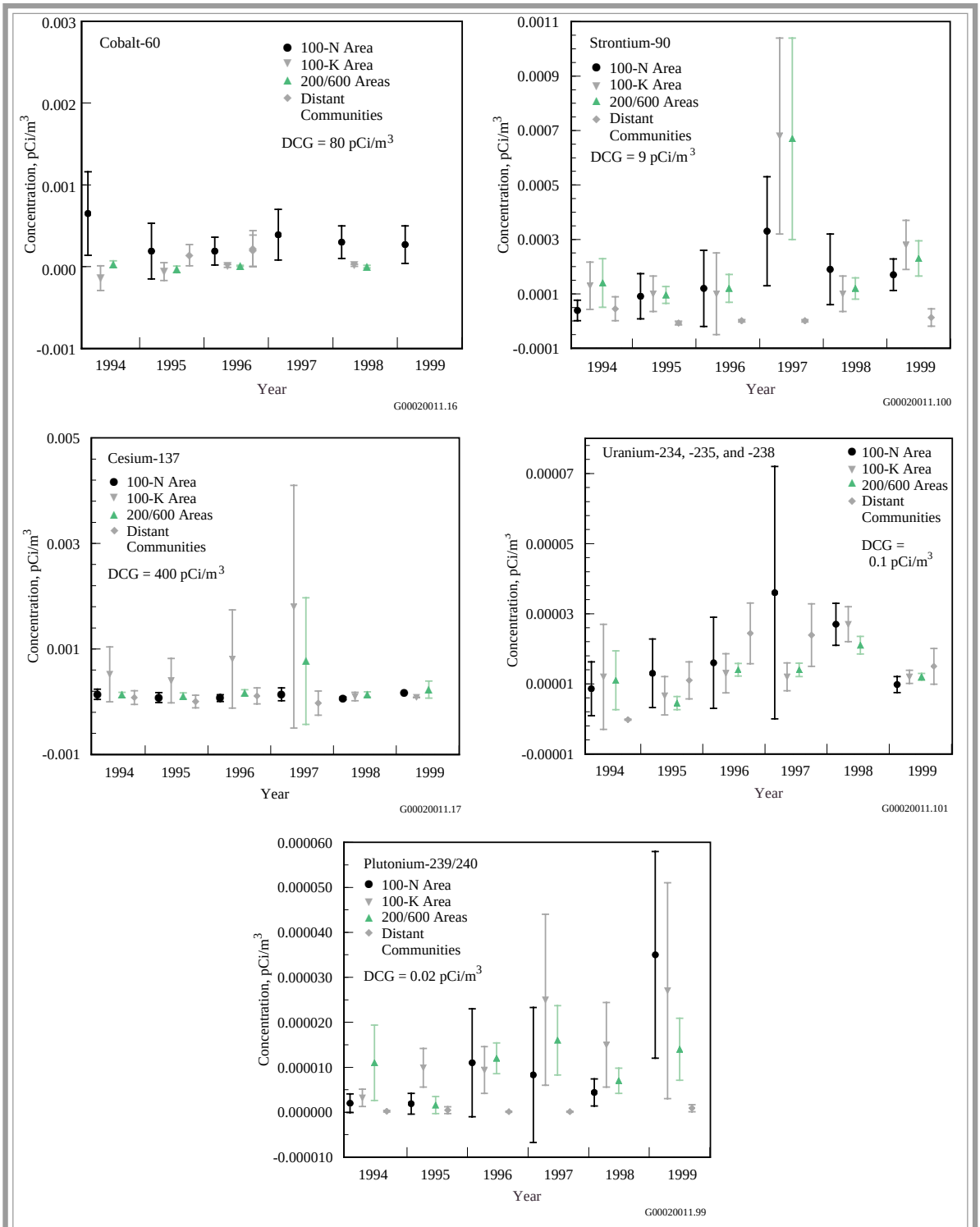


Figure 3.2.1. Average Concentration (±2 standard error of the mean) of Selected Radionuclides in Near-Facility Air Samples Compared to Those in Distant Communities, 1994 Through 1999. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. Cobalt-60 was not detected in the 100-K or 200/600 Areas in 1999. DCG = Derived concentration guide (DOE Order 5400.5).

Table 3.2.3. Annual Average and Maximum Concentrations (aCi/m^3) of Radionuclides in Near-Facility Air Samples, 1999

Cobalt-60

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	8.8 ± 25.2	36 ± 360	N465
100-D	32.2 ± 31.6	110 ± 94.6	N470
100-F/DR	11 ± 39	150 ± 210	N493
100-H	19.7 ± 19.4	66 ± 73.3	N509
100-K	6.7 ± 20.8	110 ± 100.1	N478
100-N	270 ± 230	300 ± 189	N105
200-East	-5.5 ± 15.1	75 ± 90	N976
200-West	170 ± 134.3	170 ± 134.3	N168
300-FF-1[d]	-6.5 ± 13.3	37 ± 67	N485
ERDF[e]	32.4 ± 26.9	83 ± 78.9	N483
Former Gable Mtn Pond	200 ± 440	200 ± 440	N516
Distant community[f]	-52 ± 134	234 ± 690	
DCG[g]		80,000,000	

Strontium-90

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	910 ± 1,400	2,100 ± 903	N465
100-D	250 ± 130	520 ± 156	N514
100-F/DR	310 ± 130	410 ± 205	N494
100-H	230 ± 210	310 ± 124	N509
100-K	280 ± 90	410 ± 123	N479
100-N	170 ± 58	250 ± 100	N102
200-East	230 ± 65	1,000 ± 250	N969
200-West	270 ± 57	620 ± 248	N165
300-FF-1[d]	140 ± 140	140 ± 98	N130
ERDF[e]	220 ± 310	240 ± 96	N483
Former Gable Mtn Pond	170 ± 559	170 ± 559.3	N516
Distant community[f]	13 ± 32	79 ± 37	
DCG[g]		9,000,000	

Cesium-137

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	68 ± 192.5	420 ± 462	N464
100-D	170 ± 150	210 ± 77.7	N470
100-F/DR	54.5 ± 46.4	230 ± 140.3	N495
100-H	170 ± 92	170 ± 92	N509
100-K	84 ± 61	84 ± 61	N402
100-N	170 ± 85	170 ± 85	N105
200-East	230 ± 160	320 ± 128	N158
200-West	290 ± 120	600 ± 156	N155
300-FF-1[d]	160 ± 110	160 ± 110.4	N489
ERDF[e]	19.4 ± 19.3	52 ± 61.9	N484
Former Gable Mtn Pond	-130 ± 360	-130 ± 360.1	N516
Distant community[f]	13 ± 218	390 ± 580	
DCG[g]		400,000,000	

Uranium-234

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	36 ± 21	56 ± 35.3	N464
100-D	23 ± 6.1	41 ± 21.7	N511
100-F/DR	31 ± 9.8	38 ± 19	N493
100-H	21 ± 8.9	36 ± 15.5	N507
100-K	17 ± 4	31 ± 13.3	N403
100-N	16 ± 4.8	20 ± 8.2	N105
200-East	17 ± 2.7	38 ± 15.2	N158
200-West	17 ± 2.3	40 ± 16.4	N155
300-FF-1[d]	96 ± 62	370 ± 118.4	N487
ERDF[e]	22 ± 11	35 ± 14.4	N484
Former Gable Mtn Pond	85 ± 48	85 ± 48	N516
Distant community[f]	23 ± 7	41 ± 15	
DCG[g]		90,000	

Uranium-235

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	26 ± 17	33 ± 25.4	N464
100-D	8 ± 3.5	11 ± 6.9	N467
100-F/DR	16 ± 8	34 ± 19	N492
100-H	12 ± 16	12 ± 8	N507
100-K	8.4 ± 2.9	13 ± 8.2	N477
100-N	5.3 ± 7.6	5.8 ± 4.2	N106
200-East	10 ± 4.2	40 ± 19.6	N499
200-West	9.6 ± 2.4	27 ± 11.9	N956
300-FF-1[d]	37 ± 33	150 ± 52.5	N487
ERDF[e]	8.7 ± 5.1	14 ± 7.4	N484
Former Gable Mtn Pond	31 ± 31	31 ± 31	N516
Distant community[f]	0.6 ± 1.7	6.2 ± 6.3	
DCG[g]		100,000	

Uranium-238

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	35 ± 35	96 ± 48	N464
100-D	19 ± 5.7	36 ± 19.8	N511
100-F/DR	20 ± 6.6	26 ± 13.8	N492
100-H	14 ± 4.4	18 ± 9.5	N507
100-K	12 ± 2.3	18 ± 8.8	N403
100-N	10 ± 3.4	13 ± 6.9	N106
200-East	14 ± 1.5	25 ± 11	N480
200-West	13 ± 2.1	32 ± 14.1	N155
300-FF-1[d]	53 ± 24	140 ± 49	N487
ERDF[e]	19 ± 8.6	26 ± 11.7	N483
Former Gable Mtn Pond	68 ± 46	68 ± 46	N516
Distant community[f]	22 ± 5	33 ± 15	
DCG[g]		100,000	

Table 3.2.3. (contd)

Plutonium-238

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	39 ± 23	39 ± 23	N496
100-D	5.6 ± 4.9	19 ± 16.9	N512
100-F/DR	-0.2 ± 4.7	14 ± 23.9	N492
100-H	-1.4 ± 8.9	20 ± 19	N510
100-K	0.2 ± 2.9	10 ± 20	N478
100-N	2.5 ± 5.1	10 ± 11	N105
200-East	19 ± 28	23 ± 16.6	N969
200-West	2.1 ± 2	18 ± 14	N964
300-FF-1[d]	2.3 ± 0.5	2.5 ± 7.7	N130
ERDF[e]	4.9 ± 3.4	11 ± 11	N484
Former Gable Mtn Pond	-55 ± 66	-55 ± 66	N516
Distant community[f]	-0.3 ± 0.2	0.2 ± 1.2	
DCG[g]		30,000	

Plutonium-239/240

Site	Average[a]	Maximum[b]	EDP Code[c]
100-B,C	16 ± 9.1	16 ± 9.1	N466
100-D	14 ± 8.6	38 ± 16	N470
100-F/DR	30 ± 39	61 ± 27.5	N492
100-H	8.2 ± 7.8	12 ± 7.2	N507
100-K	27 ± 24	100 ± 35	N403
100-N	35 ± 23	82 ± 29.5	N103
200-East	14 ± 6.9	64 ± 23.7	N158
200-West	23 ± 8.3	100 ± 35	N161
300-FF-1[d]	12 ± 17	12 ± 6.8	N130
ERDF[e]	6.2 ± 2.2	9.6 ± 6	N482
Former Gable Mtn Pond	4.2 ± 19	4.2 ± 19	N516
Distant community[f]	0.9 ± 0.8	3.2 ± 2.9	
DCG[g]		20,000	

Plutonium-241

Site	Average[a]	Maximum[b]	EDP Code[c]
100-K	1,300 ± 325	1,300 ± 325	N403
200-East	5 ± 890.3	810 ± 202.5	N480
Distant community[f]		Not reported	
DCG[g]		1,000,000	

Americium-241

Site	Average[a]	Maximum[b]	EDP Code[c]
100-K	29 ± 6.8	43 ± 22.8	N403
200-East	25 ± 37	29 ± 14.5	N481
Distant community[f]		Not reported	
DCG[g]		20,000	

(a) ±2 standard error of the mean, except for data points that represent a single value above detection limits. For these, the uncertainty value is the overall analytical error.
(b) ± overall analytical error.
(c) Sampler location code. See PNNL-13230, APP. 2.
(d) 300 Area.
(e) ERDF = Environmental Restoration Disposal Facility.
(f) See Section 4.1, "Air Surveillance."
(g) DOE Derived Concentration Guide.

project-specific downwind samplers. Remedial action activities for fiscal year 1999 were completed at the 100-B,C site and ambient air monitoring ended in May. At the 100-D Area, ambient air monitoring locations included nine samplers. Eight samplers, four of which were added in August 1999 to accommodate expanded activities, were dedicated to the remedial action project. One other sampler, dedicated to the 100-D stack demolition project, was in service from the end of July through the end of September 1999. At the 100-H Area, ambient air monitoring locations included four project-specific samplers, one upwind and three downwind. Consistently detectable radionuclides at the 100-H project were strontium-90 and uranium-234, and -238. Plutonium-239/240 was occasionally detectable.

Two samplers for each of the 100-F and DR interim safe storage projects were in operation in 1999. The quarterly analytical results from both projects indicated that the strontium-90 concentrations were slightly greater than levels measured off the site. Consistently detectable radionuclides were uranium-234, -235, and -238. Plutonium-239/240 was occasionally detectable.

The airborne contaminant levels in the 100-K Area were greater than levels measured off the site. Facility emissions in the 100-K Area decreased substantially in 1996, and subsequent radionuclide concentrations in the ambient air samples have been near detection limits. Consistently detectable radionuclides were uranium-234, -238, and americium-241. Occasionally detectable radionuclides included strontium-90, uranium-235, and plutonium-239/240.

Analytical results from ambient air samples taken from the 100-N Area were greater than levels measured off the site. Consistently detectable radionuclides were strontium-90, uranium-234, -238, and plutonium-239/240. Occasionally detectable radionuclides were cobalt-60 and uranium-235.

Radionuclide levels measured in the 200-East Area were greater than those measured off the site. Consistently detectable radionuclides were strontium-90 and uranium-234 and -238. Occasionally detectable radionuclides were cesium-137, uranium-235, and plutonium-239/240.

Radionuclides levels measured in the 200-West Area were also greater than those measured off the site. Consistently detectable radionuclides were strontium-90, uranium-234, -235, and -238, and plutonium-239/240. Cesium-137 was occasionally detectable.

Ambient air monitoring at the 300-FF-1 operable unit remedial action project included one near-facility monitoring upwind location at the nearby 300 Area Treated Effluent Disposal Facility; two Pacific Northwest National Laboratory upwind monitors in the 300 Area (stations #14 "300 Trench" and #15 "300 NE;" see Section 4.1, "Air Surveillance"); and five downwind, project-specific air monitors. The analytical results indicated that radionuclide concentrations in air samples collected at this site were much less than the DOE derived concentration guides but greater than levels measured off the site. The only consistently detectable radionuclides were uranium-234, -235, and -238.

The air sampling network at the Environmental Restoration Disposal Facility (200-West Area) used two existing Hanford Site monitors for upwind monitoring and three additional air monitors that provided downwind coverage. The 1999 analytical results indicated that the activities were only slightly greater than levels measured off the site. The only consistently detectable radionuclides were uranium-234, -235, and -238, and plutonium-239/240. Strontium-90 was occasionally detectable.

Air monitoring was conducted intermittently at one location from August through December 1999 at the former Gable Mountain Pond (200-CW-1) remedial investigation project. The 1999 analytical results from the composite sample detected only uranium-234 and -238 and these were at levels only slightly higher than offsite levels.

The remedial action, interim safe storage, and surveillance and maintenance/transition projects discussed above are described in more detail in Section 2.3.11, "Environmental Restoration Project." A complete listing of the 1999 near-facility ambient air monitoring results can be found in PNNL-13230, APP. 2. Results for selected Pacific Northwest National Laboratory air samples are also reported in PNNL-13230, APP. 2, as well as in Section 4.1, "Air Surveillance."

3.2.2 Surface-Water Disposal Units and 100-N Area Riverbank Springs Monitoring

The two surface-water disposal units in the 200-East Area that historically received radiologically contaminated effluents, the 200-East Area powerhouse ditch and the 216-B-3C expansion pond, were virtually unused in 1999. There was a single-batch discharge to the powerhouse ditch in February 1999, and a liquid grab sample was collected. This sample was screened for gross alpha and gross beta radioactivity and no unusual levels were observed. No further radionuclide specific analyses were performed. No aquatic vegetation or sediment samples were collected at these locations in 1999.

Water samples were also taken at riverbank springs in the 100-N Area. In the past, radioactive effluent streams sent to the 1301-N and 1325-N Liquid Waste Disposal Facilities in the 100-N Area contributed to the release of radionuclides to the Columbia River through their migration with the groundwater. Radionuclides from these facilities enter the Columbia River along the riverbank region sometimes called N Springs. Groundwater springs and/or shoreline seepage wells at the N Springs are sampled annually to verify that the reported radionuclide releases to the Columbia River are conservative (i.e., not underreported). The amount of radionuclides entering the Columbia River at these springs (i.e., release) is calculated based on analyses of monthly samples collected from monitoring well 199-N-46 located near the shoreline. Analytical results and discussion of these releases may be found in Section 3.1, "Facility Effluent Monitoring" and in HNF-EP-0527-9, "Environmental Releases for Calendar Year 1999."

In October 1999, ten samples were collected. At the time of sample collection, 3 of the 13 shoreline wells were dry, and no samples were collected at these locations. The shoreline seepage well samples were collected using a bailer, carefully lowered into each well water column to avoid sediment suspension, and a 4-liter (1-gallon) sample was obtained. Analyses of these samples included tritium, strontium-90, and gamma-emitting radionuclides.

In 1999, the levels of strontium-90 detected in samples from riverbank springs were highest in N Springs well Y303, which is nearest well 199-N-46. Strontium-90 concentrations exceeded the DOE derived concentration guide value (1,000 pCi/L) only at well Y303. The highest tritium level was measured ~122 meters (400 feet) downstream at well Y307. Tritium concentrations at all sampling locations were well below the 2,000,000 pCi/L derived concentration guide. All gamma-emitting radionuclide concentrations were below analytical detection limits in 1999. The data from 1999 riverbank springs sampling are summarized in Table 3.2.4.

Table 3.2.4. Radionuclide Concentrations (pCi/L) in 100-N Area Riverbank Springs, 1999

Radionuclide	Facility Effluent Monitoring Well 199-N-46	Shoreline Springs Maximum[a]	Shoreline Springs Average[b]	DCG[c]
Tritium	130 ± 79	270 ± 110	120 ± 49	2,000,000
Strontium-90	3,200 ± 480	1,300 ± 190	130 ± 230	1,000

(a) ± overall analytical error.
(b) ±2 standard error of the mean.
(c) DCG = DOE derived concentration guide (DOE Order 5400.5).

3.2.3 Radiological Surveys

Radiological surveys are used to monitor and detect contamination on the Hanford Site. The main types of contaminated areas are underground radioactive materials areas, contamination areas, soil contamination areas, and high contamination areas.

Underground radioactive material areas are areas that have contamination contained below the soil surface. These areas are typically "stabilized" cribs, burial grounds, covered ponds, trenches, and ditches. Barriers over the contamination sources are used to inhibit radionuclide transport to the surface environs. These areas are surveyed at least annually to document the current radiological status.

Contamination/soil contamination areas may or may not be associated with an underground radioactive material structure. A breach in the barrier of an underground radioactive materials area may result in the growth of contaminated vegetation. Insects or animals may burrow into an underground radioactive materials area and bring contamination to the surface. Vent pipes or risers from an underground structure may be a source of speck contamination (particles with a diameter less than 0.6 centimeter [0.25 inch]). Areas of contamination not related to subsurface structures can include sites contaminated with fallout from effluent stacks and sites that are the result of unplanned releases (e.g., contaminated tumbleweeds, animal feces). All radiologically controlled areas may be susceptible to contamination migration and are surveyed at least annually to document the current radiological status (locations of radiologically controlled areas are illustrated in PNNL-13230, APP. 2).

In 1999, the Hanford Site had ~3,651 hectares (9,022 acres) of posted outdoor contamination areas (all types) and 625 hectares (1,544 acres) of posted underground radioactive materials areas not including active facilities. Table 3.2.5 lists the contamination areas and underground radioactive materials areas in 1999. Vehicles equipped with radiation detection devices and a global positioning system were again used in 1999 to measure more accurately the extent of the contamination. Area measurements are entered into the Hanford Geographical Information System, a computer database maintained by Bechtel Hanford, Inc.

The number and size of contaminated areas vary from year to year because of efforts to cleanup, stabilize, and remediate areas of known contamination. New areas of contamination also are being identified, though no areas of significance were added in 1999. Table 3.2.6 indicates the changes resulting from stabilization activities during 1999. Approximately 4.3 hectares (10.6 acres) were reclassified from contamination/soil contamination areas to underground radioactive materials areas. Newly identified areas are generally the result of either contaminant migration or an increased effort to investigate outdoor areas for radiological contamination.

It was estimated that the external dose rate at 80% of the identified outdoor contamination acreage was less than 1 mrem/h, though direct dose rate readings from isolated radioactive specks could have been considerably higher.

3.2.4 Soil and Vegetation Sampling from Operational Areas

Soil and vegetation samples were collected on or adjacent to waste disposal units and from locations downwind and near or within the boundaries of operating facilities and remedial action activity sites. Samples were collected to evaluate long-term trends in environmental accumulation of radioactivity and

Table 3.2.5. Outdoor Contamination Status, 1999

Area	Contamination Areas,[a] ha (acres)		Underground Radioactive Materials Areas,[b] ha (acres)	
100-B,C	8	(20)	39	(96)
100-D,DR	0.1	(0.2)	39	(96)
100-F	0.7	(2.0)	8	(9)
100-H	0.1	(0.2)	14	(35)
100-K	9	(22)	62	(153)
100-N	41	(101)	12	(30)
200-East[c]	64	(158)	139	(343)
200-West[c]	29	(72)	222	(549)
300	19	(47)	35	(87)
400	0	0	0	0
600[d]	3,480	(8,599)	55	(136)
Totals	3,651	(9,022)	625	(1,544)

(a) Includes areas posted as contamination/soil contamination or as radiologically controlled and areas that had both underground radioactive material and contamination/soil contamination.
(b) Includes areas with only underground contamination. Does not include areas that had contamination/soil contamination as well as underground radioactive material.
(c) Includes tank farms.
(d) Includes BC controlled area and waste disposal facilities outside the 200-East Area boundary that received waste from 200-East Area facilities (e.g., 216-A-25, 216-B-3) and waste disposal facilities outside the 200-West Area boundary that received waste from 200-West Area facilities (e.g., 216-S-19, 216-U-11). The first cell of the Environmental Restoration Disposal Facility was added during 1997.

Table 3.2.6. Zone Status Change of Posted Contamination Areas, 1999[a]

Areas	Zone Changes[b]	Area, ha (acres)	
100	CA to URM	2.8	(6.9)
200-East	CA to URM	1.5	(3.7)
200-West	CA to URM	0	0
300	CA to URM	0	0
400	CA to URM	0	0
600	CA to URM	0	0

(a) Changes from stabilization activities, newly discovered sites, or resurvey using a global positioning system.
(b) CA = Contamination/soil contamination area.
URM = Underground radioactive materials area.

to detect potential migration and deposition of facility effluents. Special samples also were collected where potential physical or biological pathway problems were identified. Contaminant movement can occur as the result of resuspension from radioactively contaminated surface areas, absorption of radionuclides by the roots of vegetation growing on or near underground and surface-water disposal units, or waste site intrusion by animals. The sampling methods and locations used are discussed in detail in WMTS-OEM-001, Rev. 0. Radiological analyses of soil and vegetation samples included strontium-90, isotopic uranium, isotopic plutonium, and gamma-emitting radionuclides.

The number and location of soil and vegetation samples collected in 1999 are shown in Table 3.2.1. A comprehensive presentation of the analytical data results can be found in PNNL-13230, APP. 2. Only those radionuclide concentrations above analytical detection limits are discussed in this section.

Each soil sample represents a composite of five plugs of soil 2.5 centimeters (1 inch) deep and 10 centimeters (4 inches) in diameter collected from each site. Each vegetation sample consists of new-growth leaf cuttings taken from the available species of interest at each sample location. Often, the vegetation sample consisted of a composite of several like members of the sampling site plant community to avoid decimation of any individual plant through overharvesting.

Early in the summer of each year, soil and vegetation samples are collected on the Hanford Site and submitted for radioanalyses. The analyses include those for radionuclides expected to be found in the areas sampled (i.e., gamma-emitting radionuclides, strontium isotopes, uranium isotopes, and/or plutonium isotopes). The results are then compared to levels found at various offsite sample locations in Yakima and in Benton and Franklin Counties (PNNL-10574, PNNL-11795). Comparison of the levels can be used to determine the difference between contributions from site operations and remedial action sites and contributions from natural causes and worldwide fallout.

Soil sampling results also are compared to the "accessible soil" limits included in HNF-PRO-454, Rev. 1 developed specifically for use at the Hanford Site (see PNNL-13230, APP. 2 for complete listing). These radioactive limits were established to ensure that effective dose equivalents to the public do not exceed the established limits for any reasonable scenario, such as direct exposure, inadvertent ingestion, inhalation, and ingestion of food crops, including animal products. The conservatism inherent in pathway modeling ensures that the required degrees of protection are in place (HNF-PRO-454, Rev. 1). These limits apply specifically to the Hanford Site with respect to onsite disposal operations, stabilization and cleanup, and decontamination and decommissioning operations.

In general, radionuclide concentrations in soil and vegetation samples collected from, or adjacent to, waste disposal facilities were higher than the concentrations in samples collected farther away and were significantly higher than concentrations measured offsite. The data also show, as expected, that concentrations of certain radionuclides were higher within different operational areas when compared to concentrations measured in distant communities. Generally, the predominant radionuclides were activation and fission products in the 100-N Area, fission products in the 200 Areas, and uranium in the 300/400 Areas.

3.2.4.1 Radiological Results for Soil Samples

Of the radionuclide analyses performed, cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were consistently detectable. The concentrations of these radionuclides in soil samples were elevated near and within facility boundaries when compared to concentrations measured off the site.

Figure 3.2.2 shows average soil values for 1999 and the preceding 5 years. The levels show a large degree of variability.

Generally, the surface soil samples collected near the 1301-N Liquid Waste Disposal Facility exhibited relatively higher radionuclide concentrations than those collected at the other soil sampling locations in the 100-N Area. Average radionuclide concentrations detected in the surface soil samples near the facility from 1994 through 1999 are presented in Table 3.2.7. Generally, results were at or near historical levels measured on the Hanford Site. However, concentrations of strontium-90 and uranium-238 were somewhat elevated compared to 1998 results. Additionally, contamination levels for these radionuclides were greater than those previously measured off the Hanford Site and in the 200 and 300/400 Areas.

Average radionuclide concentrations detected in all of the surface soil samples collected in the 100-N Area from 1994 through 1999 are presented in Table 3.2.8. The average values for 100-N Area soils were down in 1999 for cobalt-60, cesium-137, uranium-235, and plutonium-239/240, the averages for strontium-90, uranium-234 and -238 were slightly elevated over the 1998 sample results. The 1999 maximum, average, offsite average concentrations, and accessible soil limits are compared in Table 3.2.9. Offsite averages for isotopic uranium, strontium-90, and cesium-137 are from PNNL-11795 and offsite values for plutonium-239/240 are contained in PNL-10574. Complete listings of radionuclide concentrations and sample location maps are provided in PNNL-13230, APP. 2.

Soil samples from 58 of 111 sample locations in the 200/600 Areas were collected in 1999. A follow-up sample location (D146) was again included this year from the southern end of the Environmental Restoration Disposal Facility (200-West Area) and is now sampled on an annual basis. The 1999 maximum, average, offsite average, and accessible soil limits are compared in Table 3.2.10. Complete listings of radionuclide concentrations and sample location maps are provided in PNNL-13230, APP. 2.

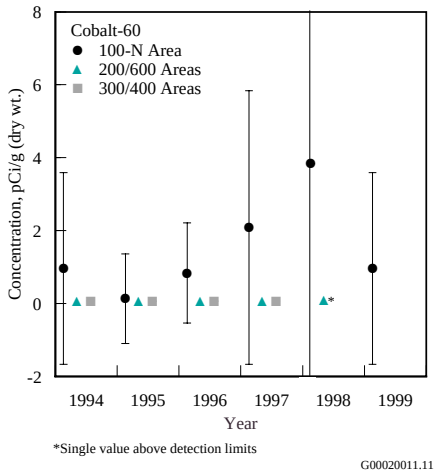
Analytical results from soil samples taken from the 200/600 Areas demonstrated somewhat higher average values for all of the radionuclides measured in 1999, with the exception of plutonium-239/240, which was slightly lower.

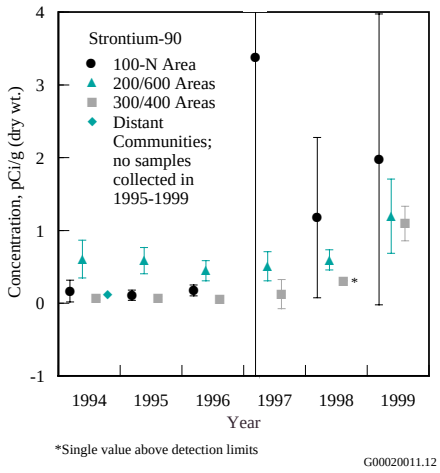
Soil samples from 13 sample locations in the 300/400 Areas were collected in 1999; 12 from the 300 Area and 1 from the 400 Area. The 1999 maximum, average, offsite average concentrations, and accessible soil limits are compared in Table 3.2.11. Complete listings of radionuclide concentrations and sample location maps are provided in PNNL-13230, APP. 2. For the samples collected in 1999, average values were slightly higher for cesium-137, strontium-90, uranium-235, and plutonium-239/240 than in 1998. Uranium was expected to be somewhat higher in these samples because it was used during past fuel fabrication operations in the 300 Area.

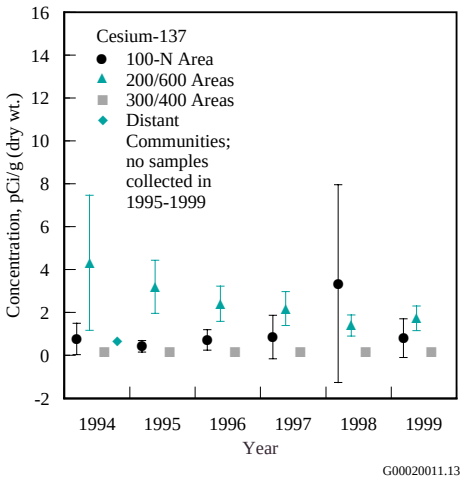
In 1999, two soil samples each were collected at the remedial action locations in the 100-B,C, 100-D, and 100-H Areas and a single sample was collected from the Environmental Restoration Disposal Facility (200-West Area) to determine the effectiveness of contamination controls. The samples collected from these locations generally represented baseline samples to be used for comparison with future samples. Table 3.2.12 provides a summary of the analytical data for selected radionuclides. All of the 1999 data are provided in PNNL-13230, APP. 2.

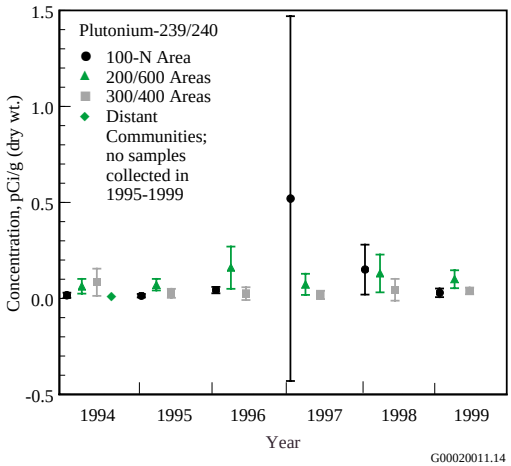
3.2.4.2 Radiological Results for Vegetation Samples

Of the radionuclide analyses performed, cobalt-60, strontium-90, cesium-137, plutonium-239/240, and uranium were consistently detectable. Concentrations of these radionuclides in vegetation were elevated near and within facility boundaries compared to the concentrations measured off the site. Figure 3.2.3 shows average vegetation values for 1999 and the preceding 5 years. The results show a high degree of variability.









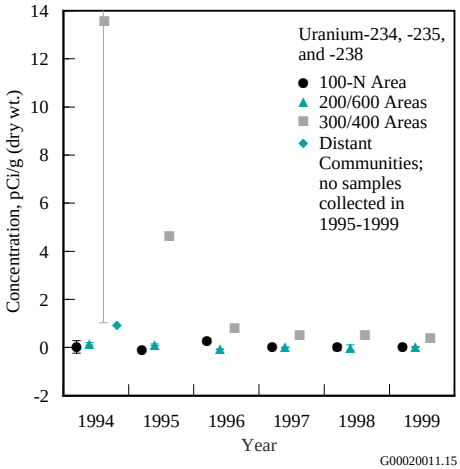


Figure 3.2.2. Average Concentration (±2 standard error of the mean) of Selected Radionulcides in Near-Facility Soil Samples Compared to Those in Distant Communities, 1994 Through 1999. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. Cobalt-60 was not detected in the 200/600 or 300/400 Areas in 1999.

Table 3.2.7. Average Radionuclide Concentrations (pCi/g dry wt.)[a] Detected in Surface Soil Samples Near the 1301-N Liquid Waste Disposal Facility, 1994 Through 1999

Year	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
1994	3.7 ± 4.8	0.33 ± 0.34	1.5 ± 1.5	0.080 ± 0.016	0.005 ± 0.002	0.080 ± 0.014	0.028 ± 0.030
1995	2.1 ± 2.2	0.15 ± 0.17	0.77 ± 0.53	0.078 ± 0.015	0.003 ± 0.001	0.081 ± 0.012	0.010 ± 0.013
1996	2.5 ± 1.5	0.23 ± 0.11	0.98 ± 0.57	0.568 ± 0.142	0.025 ± 0.023	0.563 ± 0.222	0.048 ± 0.026
1997	4.3 ± 5.2	5.8 ± 10.8	1.5 ± 1.5	0.22 ± 0.07	0.020 ± 0.004	0.218 ± 0.057	0.98 ± 1.79
1998	8.5 ± 14.4	1.6 ± 1.2	5.2 ± 7.4	0.223 ± 0.112	0.039 ± 0.007	0.160 ± 0.041	0.19 ± 0.19
1999	2.6 ± 3.5	2.9 ± 3.4	1.3 ± 1.3	0.210 ± 0.061	0.014 ± 0.004	0.190 ± 0.053	0.03 ± 0.04

(a) ±2 standard error of the mean.

Table 3.2.8. Average Radionuclide Concentrations (pCi/g dry wt.)[a] Detected in 100-N Area Surface Soil Samples, 1994 Through 1999

Year	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
1994	1.6 ± 2.1	0.19 ± 0.15	0.81 ± 0.65	0.078 ± 0.014	0.004 ± 0.001	0.079 ± 0.012	0.016 ± 0.013
1995	0.94 ± 0.98	0.13 ± 0.07	0.51 ± 0.24	0.091 ± 0.012	0.004 ± 0.001	0.097 ± 0.014	0.014 ± 0.009
1996	1.5 ± 1.1	0.20 ± 0.08	0.077 ± 0.042	0.567 ± 0.082	0.038 ± 0.021	0.566 ± 0.125	0.043 ± 0.016
1997	2.5 ± 3.0	3.9 ± 7.2	0.89 ± 0.90	0.21 ± 0.04	0.020 ± 0.002	0.207 ± 0.036	0.91 ± 1.79
1998	4.9 ± 8.4	1.2 ± 1.2	3.1 ± 4.4	0.214 ± 0.063	0.033 ± 0.008	0.166 ± 0.026	0.15 ± 0.14
1999	1.6 ± 2.1	2.0 ± 2.0	0.84 ± 0.80	0.220 ± 0.037	0.016 ± 0.004	0.200 ± 0.033	0.029 ± 0.023

(a) ±2 standard error of the mean.

Table 3.2.9. Concentration of Selected Radionuclides (pCi/g dry wt.) in 100-N Area Soil, 1999

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
Maximum[a]	6.1 ± 0.5	6.1 ± 0.9	2.4 ± 0.3	0.25 ± 0.09	0.021 ± 0.015	0.23 ± 0.08	0.068 ± 0.029
Average[b]	1.6 ± 2.1	2.0 ± 2.0	0.84 ± 0.81	0.22 ± 0.03	0.016 ± 0.003	0.20 ± 0.03	0.029 ± 0.023
Offsite average[b,c]	NR[d]	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil concentration limits (HNF-PRO-454, Rev. 1)[e]	7.1	2,800	30	630	170	370	190

(a) ± counting error.
(b) ±2 standard error of the mean.
(c) PNNL-10574 and PNNL-11795.
(d) NR = Not reported.
(e) Hanford soils that are not behind security fences.

Table 3.2.10. Concentration of Selected Radionuclides (pCi/g dry wt.) in 200/600 Areas Soil, 1999

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
Maximum[a]	ND[b]	5.9 ± 1.2	9.6 ± 1.3	0.49 ± 0.17	0.048 ± 0.034	0.50 ± 0.20	0.6 ± 0.2
Average[c]	--	1.1 ± 0.5	1.4 ± 0.5	0.23 ± 0.02	0.026 ± 0.003	0.22 ± 0.02	0.10 ± 0.05
Offsite average[c,d]	NR[e]	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil concentration limits (HNF-PRO-454, Rev. 1)[f]	7.1	2,800	30	630	170	370	190

(a) ± counting error.
(b) ND = Not detected.
(c) ±2 standard error of the mean.
(d) PNNL-10574 and PNNL-11795.
(e) NR = Not reported.
(f) Hanford soils that are not behind security fences.

Table 3.2.11. Concentration of Selected Radionuclides (pCi/g dry wt.) in 300/400 Areas Soil, 1999

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
Maximum[a]	ND[b]	1.5 ± 0.4	0.18 ± 0.03	3.9 ± 1.2	0.53 ± 0.017	3.9 ± 1.3	0.097 ± 0.04
Average[c]	ND	0.87 ± 0.19	0.093 ± 0.026	0.75 ± 0.54	0.10 ± 0.07	0.71 ± 0.53	0.040 ± 0.020
Offsite average[c,d]	NR[e]	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible soil concentration limits (HNF-PRO-454, Rev. 1)[f]	7.1	2,800	30	630	170	370	190

(a) ± counting error.
(b) ND = Not detected.
(c) ±2 standard error of the mean.
(d) PNNL-10574 and PNNL-11795.
(e) NR = Not reported.
(f) Hanford soils that are not behind security fences.

Average radionuclide concentrations detected in the vegetation samples near the retired 1301-N Liquid Waste Disposal Facility from 1994 through 1999 are presented in Table 3.2.13. In 1999, these samples had higher concentrations of cobalt-60 and plutonium-239/240 and significantly higher concentrations of strontium-90 and cesium-137 at sites Y702 and Y705 (see PNNL-13230, APP. 2) when compared to 1998 levels.

Average radionuclide concentrations detected in all of the vegetation samples collected in the 100-N Area from 1994 through 1999 are presented in Table 3.2.14.

Vegetation samples collected along the 100-N Area shoreline (N Springs) contain radionuclides that were not completely retained in the soil columns beneath the retired 1301-N and 1325-N Liquid Waste Disposal Facilities. Values for all of the

Table 3.2.12. Radionuclide Concentrations (pCi/g dry wt.) in Environmental Restoration Contractor Projects' Soil Samples, 1999

Site	Sample Location[a]	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
ERDF[b]	D-146	ND[c]	0.32 ± 0.11	ND	0.19 ± 0.07	0.012 ± 0.009	0.17 ± 0.06	ND
100-D	D-147	ND	ND	0.30 ± 0.05	0.28 ± 0.10	0.036 ± 0.023	0.26 ± 0.10	0.018 ± 0.013
100-D	D-148	ND	ND	0.30 ± 0.05	0.25 ± 0.09	0.028 ± 0.017	0.18 ± 0.07	ND
100-B,C	D-149	ND	ND	0.37 ± 0.06	0.16 ± 0.06	0.020 ± 0.016	0.19 ± 0.07	ND
100-H	D-151	ND	ND	0.79 ± 0.10	0.23 ± 0.08	0.029 ± 0.020	0.19 ± 0.07	0.047 ± 0.024
100-H	D-152	0.032 ± 0.010	ND	0.51 ± 0.07	0.19 ± 0.07	0.013 ± 0.011	0.15 ± 0.06	0.021 ± 0.015
100-B,C	D-153	ND	ND	0.38 ± 0.05	0.21 ± 0.04	0.045 ± 0.015	0.15 ± 0.03	ND
Offsite Average[d,e]		NR[f]	0.062 ± 0.052	0.30 ± 0.30	0.24 ± 0.09	0.11 ± 0.04	0.25 ± 0.10	0.011 ± 0.001
Accessible Soil Concentration[g]		7.1	2,800	30	630	170	370	190

(a) See PNNL-13230, APP. 2.
(b) ERDF = Environmental Restoration Disposal Facility.
(c) ND = Not detected.
(d) ±2 standard error of the mean.
(e) PNNL-10574 and PNNL-11795.
(f) NR = Not reported.
(g) Hanford soils that are not behind security fences.

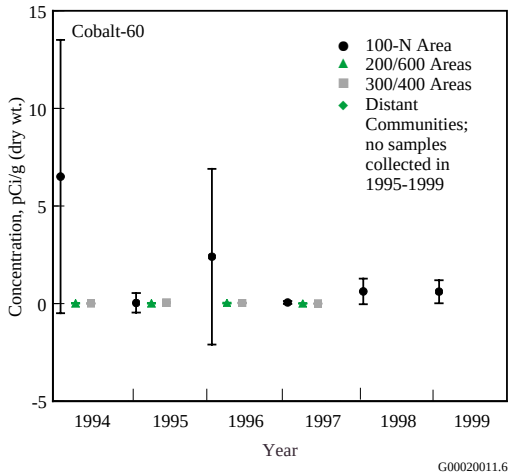
radionuclides analyzed were reduced in 1999, with the exception of cesium-137. Average radionuclide concentrations detected in the vegetation samples collected along N Springs in 1999 and during the previous 5 years are presented in Table 3.2.15.

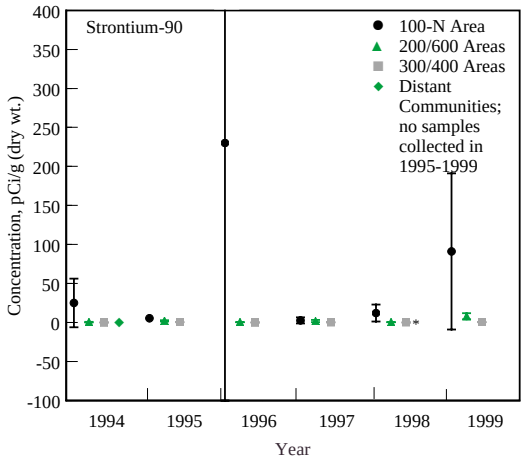
The 1999 analytical results for vegetation samples collected at the 100-N Area are compared to offsite averages in Table 3.2.16. A complete list of radionuclide concentrations and sample location maps are provided in PNNL-13230, APP. 2. Analytical results from vegetation samples collected from the 100-N Area in 1999 were elevated compared to those observed in 1998, except for the results of cobalt-60. Generally, 1999 radionuclide levels in 100-N Area vegetation were greater than those previously measured off the site; levels for cobalt-60, strontium-90, and cesium-137 were higher compared to the concentrations measured in the 200 and 300/400 Areas.

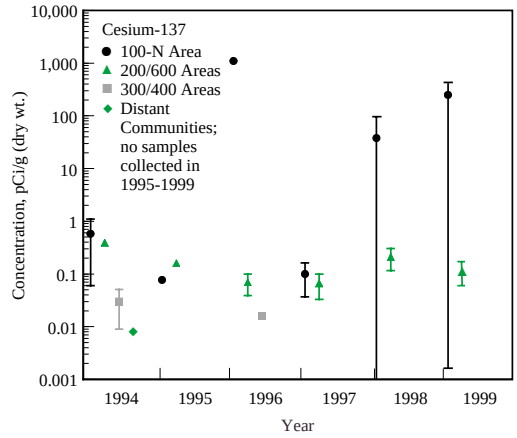
In 1999, 47 vegetation samples were collected from the 200/600 Areas. The 1999 maximum, average, and offsite average are compared in Table 3.2.17. A complete list of radionuclide concentrations and sample location maps is provided in PNNL-13230, APP. 2.

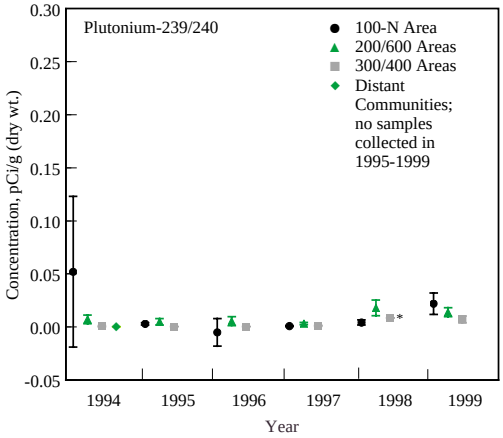
Analytical results from vegetation samples taken in 1999 from the 200/600 Areas were generally comparable to those observed in previous years. Radionuclide levels for strontium-90, cesium-137, and plutonium-239/240 were greater than those previously measured off the Hanford Site and were higher for cesium-137 and plutonium-239/240 compared to the 100 and 300/400 Areas.

This was the eighth year of sampling from locations established to more directly monitor facilities and active/inactive waste sites in the 300 and 400 Areas. The 1999 maximum, average, offsite average, and accessible soil limits for 300/400 Areas samples are listed in Table 3.2.18. Complete listings of radionuclide concentrations and sample location maps are provided in PNNL-13230, APP. 2.









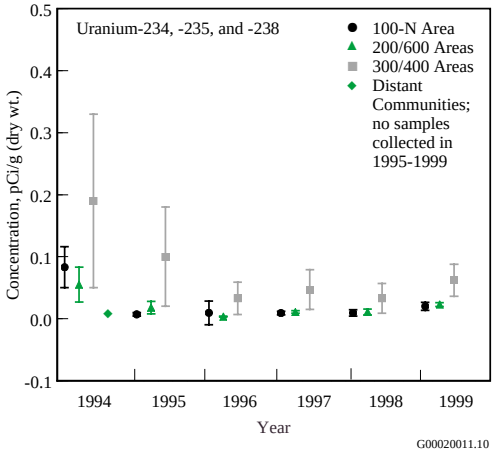


Figure 3.2.3. Average Concentration (±2 standard error of the mean) of Selected Radionulcides in Near-Facility Vegetation Samples Compared to Those in Distant Communities, 1994 Through 1999. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol. The 1997 cesium-137 data point for the 300/400 Areas is less than zero and cannot be plotted on a log scale. Cobalt-60 was not detected in the 200/600 or 300/400 Areas in 1999. Cesium-137 was not detected in the 300/400 Areas in 1999.

Table 3.2.13. Average Radionuclide Concentrations (pCi/g dry wt.)[a] Detected in Vegetation Samples Collected Near the 1301-N Liquid Waste Disposal Facility, 1994 Through 1999

Year	^{60}Co	^{90}Sr	^{137}Cs	$^{239/240}$Pu
1994	24.8 ± 31.6	4.8 ± 6.9	1.8 ± 1.8	0.20 ± 0.27
1995	0.054 ± 0.10	0.064 ± 0.019	0.12 ± 0.14	0.008 ± 0.003
1996	6.1 ± 11.9	575 ± 1,150	2,750 ± 5,500	-0.013 ± 0.38[b]
1997	0.42[c]	0.49[c]	0.14 ± 0.06	ND[d]
1998	0.54 ± 0.93	13.6 ± 26.4	50.1 ± 99.8	0.0071[c]
1999	0.99 ± 0.97	205 ± 201	505 ± 410	0.009 ± 0.010

(a) ±2 standard error of the mean.
(b) Negative value indicates results at or below background levels of radioactivity.
(c) Single value above detection limit.
(d) ND = Not detected.

Table 3.2.14. Average Radionuclide Concentrations (pCi/g dry wt.)[a] Detected in 100-N Area Vegetation Samples, 1994 to 1999

Year	^{60}Co	^{90}Sr	^{137}Cs	$^{239/240}$Pu
1994	6.5 ± 8.5	25 ± 33	0.58 ± 0.52	0.053 ± 0.071
1995	0.03 ± 0.05	5.4 ± 4.8	0.081 ± 0.044	0.0033 ± 0.0016
1996	2.4 ± 4.5	230 ± 430	1,100 ± 2,000	-0.0051 ± 0.013[b]
1997	0.42 ± 0.05	3.6 ± 5.3	0.16 ± 0.008	ND[c]
1998	0.62 ± 0.73	11.7 ± 11.1	37.6 ± 74.9	0.0042 ± 0.0029
1999	0.61 ± 0.59	91 ± 100	250 ± 250	0.022 ± 0.010

(a) ±2 standard error of the mean.
(b) Negative value indicates results at or below background levels of radioactivity.
(c) ND = Not detected.

Generally, the levels of most radionuclides measured in the 300 Area were greater than those measured off the site, and uranium levels were higher than measured in the 100 and 200 Areas. The higher uranium levels were expected because uranium was released during past fuel fabrication operations in the 300 Area. The levels recorded for most other radionuclides in the 400 Area were higher than those measured off the site in previous years.

3.2.5 External Radiation

External radiation fields were monitored near facilities and waste handling, storage, and disposal sites to measure and assess the impacts of operations. Thermoluminescent dosimeters are used at numerous fixed locations to gather dose rate information over longer periods of time. Thermoluminescent dosimeter results can be used individually or averaged to determine dose rates in a given area for a particular

Table 3.2.15. Average Radionuclide Concentrations (pCi/g dry wt.)[a] Detected in N Springs Vegetation Samples, 1994 to 1999

Year	^{60}Co	^{90}Sr	^{137}Cs	$^{239/240}$Pu
1994	0.14 ± 0.10	60 ± 81	0.15 ± 0.14	0.002 ± 0.001
1995	0.014 ± 0.045	13.4 ± 10.2	0.094 ± 0.059	0.0028 ± 0.0008
1996	0.01 ± 0.01	2.4 ± 4.2	0.038 ± 0.010	-0.0015 ± 0.002[b]
1997	ND[c]	6.2 ± 9.9	0.18 ± 0.17	ND
1998	0.068[d]	21.0 ± 19.0	ND	0.0028[d]
1999	ND	0.98 ± 0.80	0.28 ± 0.49	ND

(a) ±2 standard error of the mean.
(b) Negative value indicates results at or below background levels of radioactivity.
(c) ND = Not detected.
(d) Single value above detection limit.

Table 3.2.16. Concentration of Selected Radionuclides (pCi/g dry wt.) in 100-N Area Vegetation, 1999

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
Maximum[a]	2.4 ± 0.2	460 ± 69	980 ± 127	0.051 ± 0.028	0.046 ± 0.027	0.04 ± 0.02	0.033 ± 0.023
Average[b]	0.61 ± 0.59	91 ± 100	250 ± 250	0.028 ± 0.001	0.015 ± 0.010	0.021 ± 0.007	0.022 ± 0.010
Offsite average[b,c]	NR[d]	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND[e]	0.013 ± 0.004	0.00018 ± 0.00013

(a) ± counting error.
(b) ±2 standard error of the mean.
(c) PNNL-10574 and PNNL-11795.
(d) NR = Not reported.
(e) ND = Not detected.

sampling period. A summary of the 1999 thermoluminescent dosimeter results can be found in Table 3.2.19. Individual thermoluminescent dosimeter results and locations are provided in PNNL-13230, APP. 2. Specific information regarding external radiation sampling methods and locations can be found in WMTS-OEM-001, Rev. 0.

The environmental thermoluminescent dosimeters measure dose rates from all types of external radiation sources. These sources include cosmic radiation, naturally occurring radioactivity in air and soil, and fallout from nuclear weapons testing, as well as any contribution from Hanford Site activities. These outside radiation sources cause an estimated 20% deviation in results from the thermoluminescent dosimeter analyses. The results are reported in units of millirems per year.

Near-facility monitoring uses the Harshaw thermoluminescent dosimeter system, which includes the Harshaw 8807 dosimeter and the Harshaw 8800 reader. The packaging, which uses an O-ring seal, protects the dosimeter from light, heat, moisture, and dirt. The thermoluminescent dosimeters were placed 1 meter (3.3 feet) above the ground near facilities, active and inactive surface-water disposal sites, and remedial action projects. The dosimeters were exchanged and analyzed each calendar quarter. The Radiological Calibrations Facility in the

Table 3.2.17. Concentration of Selected Radionuclides (pCi/g dry wt.) in 200/600 Areas Vegetation, 1999

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
Maximum[a]	ND[b]	6.5 ± 13	0.49 ± 0.22	0.11 ± 0.05	0.035 ± 0.023	0.066 ± 0.031	0.031 ± 0.024
Average[c]	ND	0.79 ± 0.38	0.13 ± 0.04	0.033 ± 0.006	0.015 ± 0.003	0.023 ± 0.004	0.014 ± 0.004
Offsite averages[c,d]	NR[e]	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND	0.013 ± 0.004	0.00018 ± 0.00013

(a) ± counting error.
(b) ND = Not detected.
(c) ±2 standard error of the mean.
(d) PNNL-10574 and PNNL-11795.
(e) NR = Not reported.

Table 3.2.18. Concentration of Selected Radionuclides (pCi/g dry wt.) in 300/400 Areas Vegetation, 1999

	^{60}Co	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	$^{239/240}$Pu
Maximum[a]	ND[b]	0.64 ± 0.16	ND	0.42 ± 0.13	0.033 ± 0.015	0.39 ± 0.12	0.011 ± 0.009
Average[c]	ND	0.45 ± 0.07	ND	0.094 ± 0.053	0.017 ± 0.004	0.89 ± 0.059	0.0071 ± 0.0032
Offsite averages[c,d]	NR[e]	0.025 ± 0.012	0.0072 ± 0.0083	0.014 ± 0.006	ND	0.013 ± 0.004	0.00018 ± 0.00013

(a) ± counting error.
(b) ND = Not detected.
(c) ±2 standard error of the mean.
(d) PNNL-10574 and PNNL-11795.
(e) NR = Not reported.

Table 3.2.19. Thermoluminescent Dosimeter Results for Waste Handling Facilities, 1998 and 1999, mrem/year Based on 24 hours/day

Area	No. of Locations, 1999	1998 Maximum	1998 Mean	1999 Maximum	1999 Mean	% Change[a]
100-H	3	NA	NA	99	95	NA
100-B	5	110	97	100	90	-7
100-D	5	125	96	97	91	-5
100-K	11	720	180	370	125	-30
100-N	14	7,000	1,600	6,500	1,400	-13
200/600	66	320	100	2,000	140	40
TWRS[b]	10	88	86	90	88	2
ERDF[c]	3	100	95	94	91	-4
300	8	210	110	220	110	0
300 TEDF[d]	6	89	83	90	85	2
400	7	87	84	90	87	1
CVD[e]	4	NA	NA	120	85	NA

(a) Numbers indicate a decrease (-) or increase from the 1998 mean.
(b) TWRS = Tank Waste Remediation System Phase I demonstration project.
(c) ERDF = Environmental Restoration Disposal Facility.
(d) TEDF = 300 Area Treated Effluent Disposal Facility.
(e) CVD = Cold Vacuum Drying Facility.

318 Building (300 Area) calibrates the response of the chips; results are reported in terms of external dose.

To evaluate environmental restoration activities at the former 116-B-11 and 116-C-1 Liquid Waste Disposal Facilities, four thermoluminescent dosimeter monitoring sites were established during the fourth quarter of 1997. An additional dosimeter location, collocated with a Washington State Department of Health dosimeter, was established during the fourth quarter of 1999. Dose rates measured at these locations were 7% lower compared to the data from 1998. The 1999 average dose rate was 90 mrem/yr, comparable to the offsite ambient background average of 92 mrem/yr.

This was the fourth year that thermoluminescent dosimeters were placed in the 100-D,DR Area to evaluate cleanup activities at the former 116-D-7 and 116-DR-9 Liquid Waste Disposal Facilities. Dose rates measured at these locations were 5% lower than the results of 1998, with an average dose of 91 mrem/yr, comparable to the offsite ambient background average of 92 mrem/yr.

To evaluate environmental restoration activities in the 100-H Area, three new thermoluminescent dosimeter monitoring sites were established for the last three quarters of 1999. Because only three quarters of data were collected at these sites, the thermoluminescent dosimeter results were extrapolated to one year, resulting in an average of 96 mrem/yr, comparable to the offsite ambient background average of 92 mrem/yr.

The cleanup activities at the K Basins and adjacent retired reactor buildings in the 100-K Area continue to be monitored. Dose rates in this area decreased 30%, with an average of 125 mrem/yr, because of the removal of radioactive waste stored in proximity to the three thermoluminescent dosimeter locations.

During the fourth quarter of 1999, four new thermoluminescent dosimeter monitoring sites were established around the Cold Vacuum Drying Facility to perform preoperational monitoring. Because only one quarter of data was collected at these sites, the thermoluminescent dosimeter results were extrapolated to one year, resulting in an average of 85 mrem/yr, which is comparable to offsite ambient background levels.

The 1999 results for the 100-N Area indicate that direct radiation levels are highest near facilities that had contained or received liquid effluent from N Reactor. These facilities primarily include the retired 1301-N and 1325-N Liquid Waste Disposal Facilities. The results for these two facilities were noticeably higher than those for other 100-N Area thermoluminescent dosimeter locations, and were ~5% higher than dose levels measured at these locations in 1998. Overall, the average dose rate measured in the 100-N Area in 1999 was ~13% lower than that measured in 1998.

Dose rates were measured at the N Springs shoreline to determine potential external radiation doses to the public as well as to onsite workers. Because of the "skyshine" effect (i.e., radiation reflected by the atmosphere back to the earth's surface) from the retired 1301-N facility, dose rates at the N Springs shoreline were elevated (greater than 100 mrem/yr), which is the DOE annual external dose limit to members of the public. However, neither a member of the public nor a Hanford worker would conceivably spend an entire year at the N Springs; therefore, the values shown in Figure 3.2.4 are for comparison only.

Annual average thermoluminescent dosimeter results at 100-N Area from 1987 through 1999 are presented in Figure 3.2.5.

The highest dose rates in the 200 Areas were measured near waste handling facilities. The location within the 200 Areas exhibiting the highest dose rate was at tank farm A in the 200-East Area. The average annual dose rate measured in 1999 (110 mrem/yr) was 6% higher than the average 1998

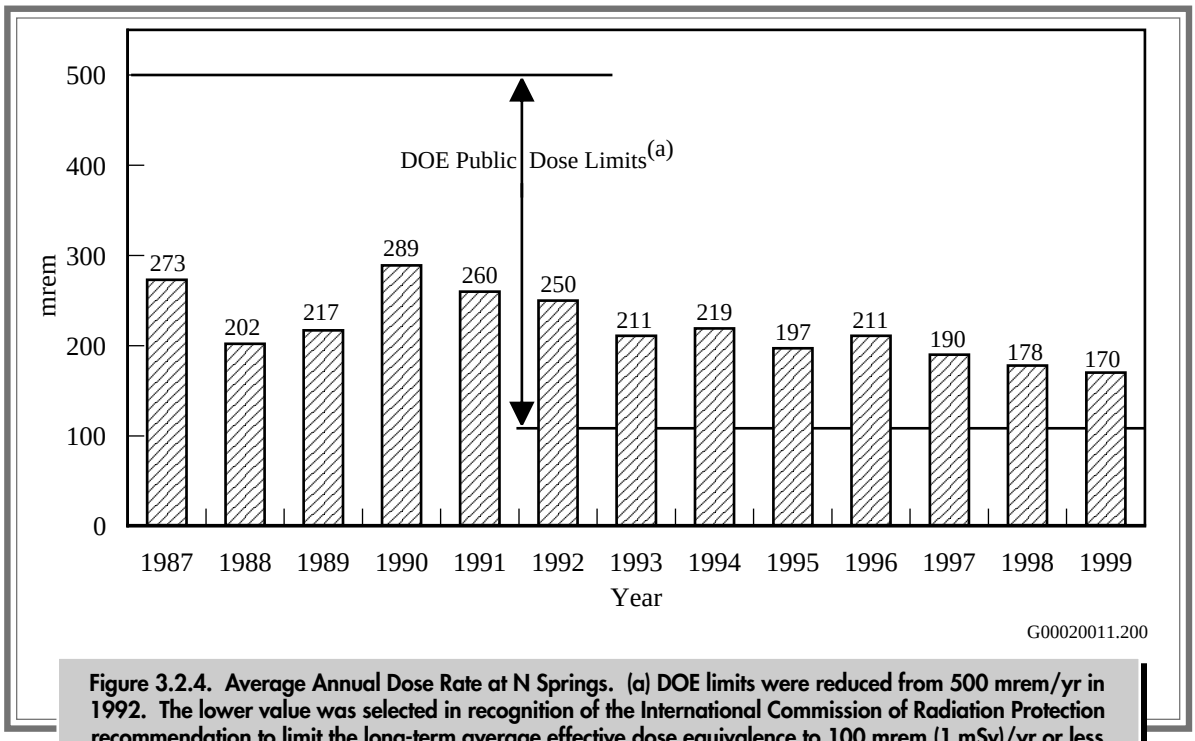


Figure 3.2.4. Average Annual Dose Rate at N Springs. (a) DOE limits were reduced from 500 mrem/yr in 1992. The lower value was selected in recognition of the International Commission of Radiation Protection recommendation to limit the long-term average effective dose equivalence to 100 mrem (1 mSv)/yr or less (DOE Order 5400.5).

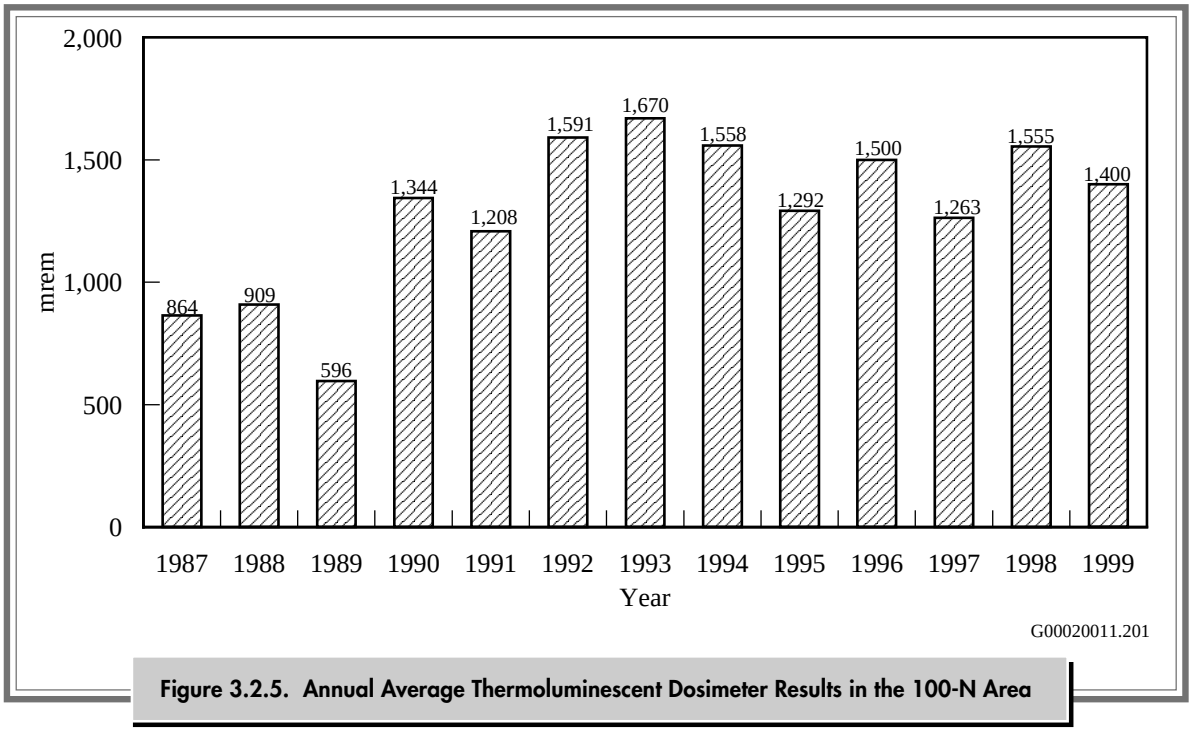


Figure 3.2.5. Annual Average Thermoluminescent Dosimeter Results in the 100-N Area

measurement. The annual average thermoluminescent dosimeter results from 1987 through 1999 are presented in Figure 3.2.6.

Ten thermoluminescent dosimeter locations were established around the perimeter of the Tank Waste Remediation System Phase I demonstration project during the fourth quarter of 1997 to collect preoperational monitoring data. Dose rates measured at these locations in 1999 were comparable to the results of 1998, with an average of 88 mrem/yr. This is comparable to offsite ambient background levels.

This is the third year that thermoluminescent dosimeters have been placed at the Environmental Restoration Disposal Facility to evaluate dose rates during ongoing activities. Dose rates measured in 1999 were slightly lower than the 1998 results, with an average of 91 mrem/yr, which is comparable to offsite ambient background levels.

The highest dose rates in the 300 Area in 1999 were measured near the 316-3 process trench. The average dose rate measured in the 300 Area in 1999 was 110 mrem/yr, which is equal to the average dose rate measured in 1998. The average dose rate at the 300 Area Treated Effluent Disposal Facility in 1999 was 85 mrem/yr, which is a 2% increase compared to the average dose rate measured in 1998. The average dose rate measured in the 400 Area in 1999 was 87 mrem/yr, which is a 1% decrease to the average dose of 86 mrem/yr measured in 1998. The annual average thermoluminescent dosimeter results from 1991 through 1998 are presented in Figure 3.2.7.

One new thermoluminescent dosimeter monitoring site was established in the 200 North Area, at the (contaminated) 212-R Railroad Car Disposition Area during the second half of 1999 to monitor expected high radiation levels in the immediate vicinity. Because only two quarters of data were collected at this site, the thermoluminescent dosimeter results were extrapolated to one year, resulting in 1,900 mrem/yr. This value exceeds the DOE annual external dose (greater than 100 mrem/yr) limit to the members of the public. However, no member of the public, or Hanford worker, would conceivably spend an entire year at this location.

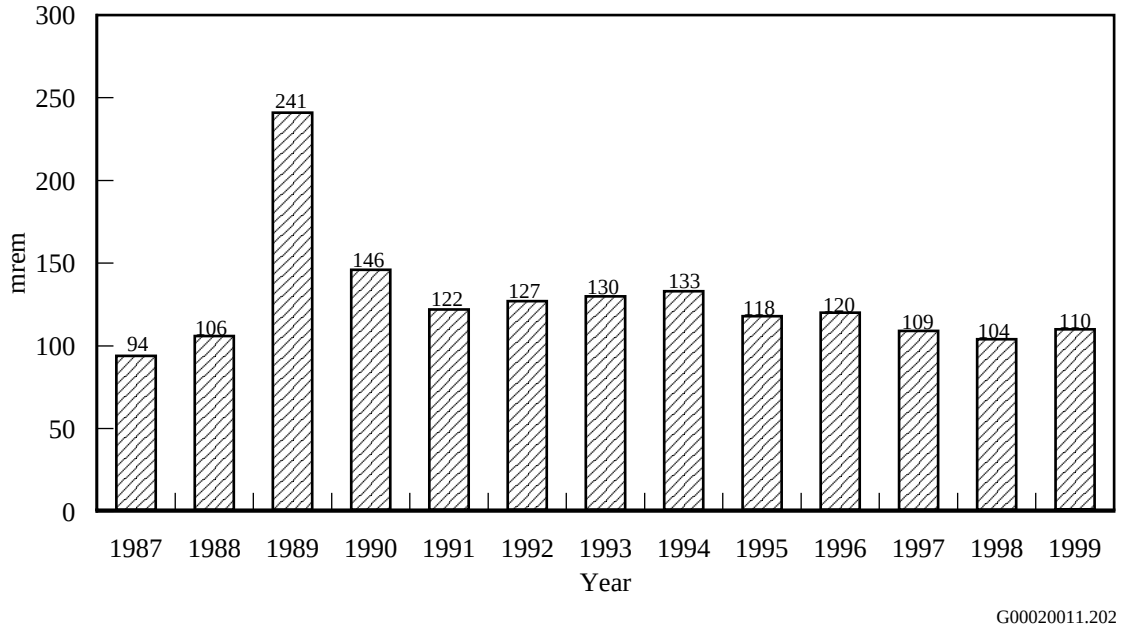


Figure 3.2.6. Annual Average Thermoluminescent Dosimeter Results in the 200 Areas

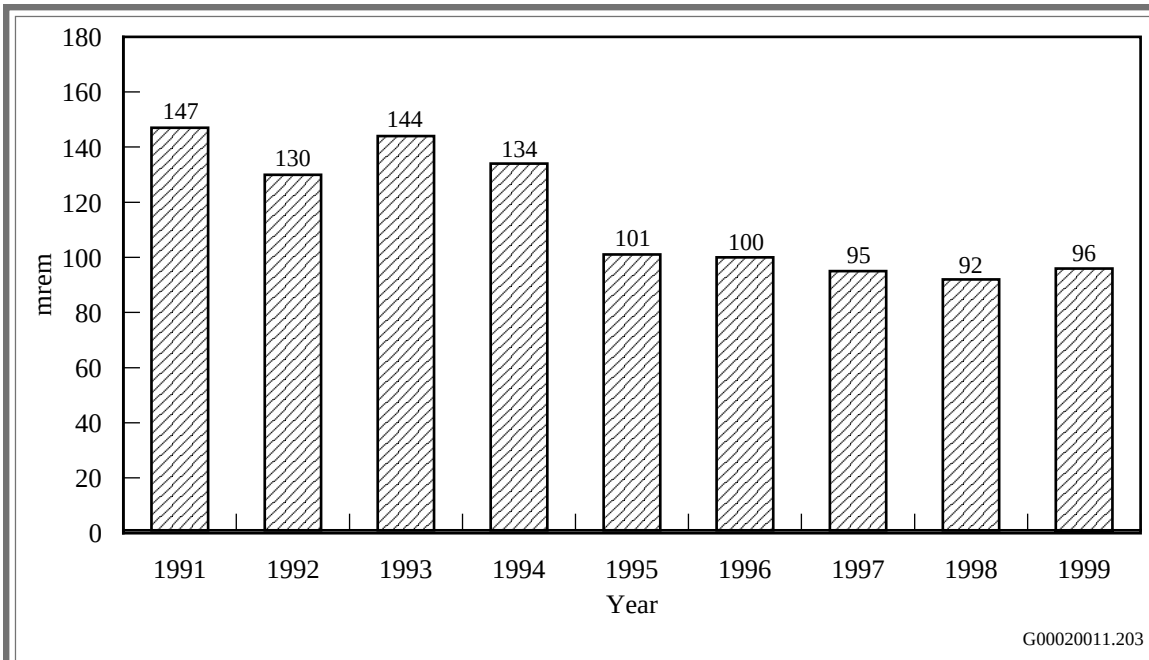


Figure 3.2.7. Annual Average Thermoluminescent Dosimeter Results in the 300/400 Areas and at the 300 Area Treated Effluent Disposal Facility

3.2.6 Investigative Sampling

Investigative sampling was conducted in the operations areas to confirm the absence or presence of radioactive and/or hazardous contaminants where known or suspected radioactive contamination was present or to verify radiological conditions at specific project sites. Investigative sampling took place near facilities such as storage and disposal sites for at least one of the following reasons:

- to follow up radiological surface surveys that had indicated radioactive contamination was present
- to conduct preoperational surveys to characterize the radiological/chemical conditions at a site before facility construction, operation, or ultimate remediation
- to determine if biotic intrusion (e.g., animal burrows or deep-rooted vegetation) has created a potential for contaminants to spread
- to determine the integrity of waste containment systems.

Generally, the predominant radionuclides discovered during these efforts were activation and fission products in the 100 and 200 Areas and uranium in the 300 Area. Hazardous chemicals generally have not been identified above background levels in preoperational environmental monitoring samples.

Investigative samples collected in 1999 included vegetation (tumbleweeds), nests (bird, wasp, ant), mammal feces (rabbit), mammals (mice, bat), and insects (fruit flies).

Methods for collecting investigative samples are described in WMTS-OEM-001, Rev. 0. Field monitoring was conducted to detect radioactivity in samples before they were submitted for analysis. Field monitoring results are expressed as disintegrations per minute when a Geiger-Müeller detector is used or as millirad per hour when an ion chamber is used. To

obtain the field instrument readings, measured background radioactivity was subtracted from the Geiger-Müeller readings (in counts per minute) and converted to disintegrations per minute per 100 cm^2. Laboratory sample analysis results are expressed in picocuries per gram, except for extremely small samples. Small samples are expressed in picocuries per sample. Maximum activities, rather than averages, are presented in this section.

In 1999, 17 investigative samples were analyzed for radionuclides at the 222-S Laboratory in the 200-West Area. Of the samples analyzed, 16 showed measurable levels of activity. Analytical results are provided in PNNL-13230, APP. 2. Another 149 contaminated investigative environmental samples were reported and disposed of without isotopic analyses (though field instrument readings were recorded) during cleanup operations. These results are also provided in PNNL-13230, APP. 2. Only radionuclide activities above analytical detection limits are provided in this section.

In 1999, there were 42 instances of radiological contamination in investigative soil samples. Of the 42, 29 were identified only as speck contamination. One investigative sample was collected for radioisotopic analysis, and 43 contaminated soils or specks were found during cleanup operations and disposed of in low-level burial grounds without analysis. External radioactivity levels ranged from 8,400 dpm/100 cm^2 to more than 1,000,000 dpm/100 cm^2. The contaminated areas were radiologically posted or cleaned up.

In 1999, there were 85 instances of radiological contamination in investigative vegetation samples. Of the 85, 82 were identified as tumbleweed, 1 as bunchgrass, and 2 as vegetation. Three tumbleweed samples were analyzed for radionuclide activities. There were 14 tumbleweed samples with field readings above 1,000,000 dpm/100 cm^2. Of these, 7 were suspected to have originated from the 218-E-12B burial ground in the 200-East Area, and the other 7 from process facilities or transfer line corridors.

The number of contaminated vegetation incidents in 1998 (51) was the highest number of annual incidents in recent years. In 1999, an even higher number of incidents occurred (85). These high numbers can be attributed largely to situations in which herbicide applications were not made at optimum times, and in some cases, not made at all. Application techniques have improved, and administrative procedures have been implemented to improve vegetation management. Nevertheless, contaminated weeds that grew in recent years continued to be identified by radiological surveys.

The number of investigative soil contamination incidents, range of radiation dose levels, and radionuclide concentrations in 1999 were generally within historical values (WHC-MR-0418). Areas of special soil sampling that were outside radiological control areas and had levels greater than radiological control limits were cleaned up or posted as surface contamination areas. Investigative vegetation samples not sent to the laboratory for analysis were disposed of in low-level burial grounds.

Investigative wildlife samples were collected directly from or near facilities to monitor and track the effectiveness of measures designed to deter animal intrusion. Wildlife is collected either as part of an integrated pest management program designed to limit the exposure to, and potential contamination of, animals with radioactive material, or as a result of finding radiologically contaminated wildlife-related material (e.g., feces, nests) during a radiation survey.

Radiological surveys were performed after the collection of wildlife to determine whether an animal was radioactively contaminated. If a live animal was found to be free of contamination, it was taken to an area of suitable habitat, still in a controlled area, and released. If an animal was contaminated, a decision was made based on the level of contamination, location, and frequency of occurrence either to collect the animal as a sample or to dispose of the animal in a low-level burial ground.

In 1999, nine wildlife and wildlife-related samples were submitted for analysis. This compares to 34 samples collected in 1998, 22 in 1997, 37 in 1996, 22 in 1995, and 16 in 1994. The number of samples submitted for analysis depended on opportunity (i.e., resulting from the pest control activities) and analytical budget, rather than prescheduled sampling at established sampling points. In 1998, 15 fruit flies were gathered as a result of a newly identified pathway of contamination. Only two contaminated fruit flies were identified in 1999. These two are suspected to be dried carcasses remaining in an unoccupied facility from the fall of 1998.

Seven of the nine wildlife-related samples showed detectable levels of radiological contamination. The exceptions were a house fly, which was associated with relatively low field readings of 7,500 dpm/100 cm^2, and some coyote feces that did not show field readings.

The maximum radionuclide concentrations in 1999 were in mouse feces collected near the 241-A lift station, near A tank farm in the 200-East Area. Contaminants included strontium-90 (394,000 pCi/g), cesium-137 (75,400 pCi/g), and total uranium (1,150,000 pCi/g). The numbers of animals found to be contaminated with radioactivity, their radioactivity levels, and the range of radionuclide activities were within historical levels (WHC-MR-0418).

There were 14 cases of contaminated wildlife or related samples found during cleanup operations that were not submitted to a laboratory for analysis. These samples included dogs (field readings indicated that the contamination was attributable to radon, and the animals were released to the Benton County Humane Society), mice, mouse feces, and mouse traps. The field instrument readings for these samples ranged from ~100 to more than 10,000,000 dpm/100 cm^2.

Special characterization projects conducted or completed in 1999 to verify the radiological, and in some cases, potential hazardous chemical status of site operations included the projects listed below.

- A preoperational environmental survey of the Project W-314 pipeline to be constructed in the 200-East Area was completed. This effort was in support of the Tank Waste Remediation System's plan to provide needed upgrades for waste transfer control and instrumentation for existing tank farm facilities. A final report (HNF-4401, Rev. 0) was prepared and issued.
- A preoperational environmental survey is planned in support of the Spent Nuclear Fuels Project Facilities. Environmental samples are being collected in the proximity of the Canister Storage Building and the Interim Storage Area in the 200-East Area and near the Cold Vacuum Drying Facility in the 100-K Area. A Sampling and Analysis Plan (HNF-SD-SNF-AP-003) was prepared and issued.